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Edited by E. Haldeman-Julius

A History of Evolution

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There is but thing greater than to search after the natural laws which govern our universe—that is to discover them.

FOREWORD

Nothing can be more nearly a truism than the statement that everything in the known universe is the product of some sort of evolution. At the same time, there is hardly a doctrine in the civilized world that has aroused more enthusiasm, interest, and enmity, than the doctrine of organic evolution. And yet I have found, to my great surprise, that few of us are accustomed to thinking of that doctrine itself as a product of a long process of evolution, covering more than twenty-six centuries. We are all too apt to think of the doctrine of organic evolution as beginning with Darwin and ending with Huxley and Haeckel; as a matter of fact, it began (so far as we can tell) with Thales, and shall not end so long as human beings inhabit this planet.

It is with the idea of presenting, in a condensed form, the essentials of this "evolution of evolution" that I have prepared this book. It is neither detailed nor technical; it does not assume to be a complete history of the subject under consideration. But it does give a convenient, readable account of the most important stages in that history, and at the same time a slight glimpse of the major characters who made it possible. This latter, unfortunately, is difficult for two reasons. The space of this booklet is limited, and only brief sketches

can be given, where they can be given at all. But more important than that is the lack of material. No scientist has been a Shakespeare, to be written about by Goethe and Frank Harris, nor yet a Cromwell, to receive the attention of Carlyle. And yet the personality and fortunes of a scientist are just as important in judging his place in the world as are those of a poet or statesman. Without knowing that Lamarck was poor and blind we cannot properly view his efforts; without realizing that Cuvier was spoiled, wealthy, and of a "ruling class," we cannot understand his bitter contempt for an honest, capable worker who was founding one of the greatest conceptions of all human thought. And so, while we are considering the ideas that go to make up this evolution, let us remember that those ideas were worked out by *men*, not by erratic, thinking machines which popular magazines proclaim to the world as representations of its scientists.

C. L. F.

CHAPTER I.

EVOLUTION AMONG THE GREEKS.

The earliest known books on natural history, and particularly on zoology, the science of animals, were those written by the ancient Greeks. We are certain that still more ancient volumes once existed, for the Greek writers commonly referred to "the ancients," very much as authors of today refer to the Greeks. But who these ancients were, where they lived, and what they wrote, we have no means of knowing; for all practical purposes the study of animal life may be considered to have originated in Greece during the seventh century before the Christian era.

Never, perhaps, has a talented people been so advantageously situated with relation to a stimulating environment as were the Greeks. All about them was a sea teeming with low and primitive forms of life, stimulating them to the observation of nature. Their earliest philosophies were philosophies of nature, of the beginnings and causes of the universe and its inhabitants. Of course, as has been pointed out by various students of philosophy, the Greeks did not follow truly scientific methods of thought; they aimed directly at a theory without stopping to search for a mass of facts to suggest and support it. Neither, for that matter, can they justly be called scientists or naturalists; rather, they were poets and phi-

losophers, and their evident failures to understand the problems which they attacked are quite to be expected. As has been said, they sought the theory before they searched for the fact, and having attained it they interpreted all facts in the light of the theory. And if that was wrong—as it very often was—the whole thing was wrong, because only the theory was studied and no one knew anything about the mistake.

But with all their superstitions and erroneous ideas, the Greeks possessed an overpowering curiosity regarding the multitudinous natural objects which they saw about them. Thales, an Ionian astronomer who lived from 624-548 B. C. was the first, so far as we know, to substitute a natural explanation of "creation" for the prehistoric myths. He believed that water was the fundamental substance from which all things come, and because of which they exist. Thus the idea of the marine origin of life, held today by many prominent biologists, is found to be extremely ancient. Of course, had Thales lived in a land-locked country instead of one surrounded by a warm, highly populated sea, his ideas might well have been different. Thus we must, at the very outset, attribute to environment as well as to intellect the reliability of an important Greek idea.

Anaximander (611-547), another astronomer, was the first important Greek evolutionist. He believed that the earth first existed in a fluid state. From its slow drying up were produced all living creatures, the first being man. These

water-dwelling humans appeared as fishes in the sea, and came out upon the land only when they had so far developed that they were able to live in the air. The capsule-like case which enclosed their bodies then burst, freeing them and allowing them to reproduce their kind upon the continents. In his ideas of the origin of life Anaximander was the pioneer of "Abiogenesis," teaching that eels, frogs, and other aquatic creatures were directly produced from lifeless matter.

Anaximander's pupil, Anaximenes, departed radically from the teachings of Thales. He thought that air, not water, was the cause of all things, yet he held that in the beginning all creatures were formed from a primordial slime of earth and water. Another pupil of Anaximander, Xenophanes (576-480), made himself famous by discovering the true nature of fossils. Before his time, and indeed, for thousands of years afterward, fossils were held to be accidents, or natural growths, or creations of a devil, or of a god who delighted in puzzling his earthly children. Xenophanes rightly interpreted them to be the remains of animals, and from this concluded that seas formerly covered what is now dry land.

Empedocles, (495-435) taught what is probably the first clearly formulated theory of evolution. He supposed that many parts of animals, such as heads, legs, necks, eyes, ears, and so on, were formed separately, and were kept apart by the mysterious forces of hate. But love of part for part finally overcame the

baser passion, and the various sections came together to form bodies. The combinations, unfortunately, were entirely accidental, and did not always result in satisfactory creatures. One body, for example, might possess several heads and no legs; another might have an abundance of arms and legs, but be without a head. These monstrosities were unable to keep themselves alive, and so perished, leaving the world to the bodies that had come together in proper combinations. Thus Empedocles, more than two thousand years before the first zoologist framed and taught a theory of organic evolution that seemed to offer anything worth while, conceived one of the most important of evolutionary principles—that of natural selection.

But by far the most striking figure among the early Greek philosophers who gave their attention to natural history was Aristotle, (384-322). He lived more than three hundred years before the Christian era, and was a pupil of Plato and a teacher of Alexander the Great. He wrote upon a wide variety of subjects—politics, rhetoric, metaphysics, psychology, philosophy, and natural history—and published several hundred works, most of which have been lost. It is true that Aristotle's books are full of errors, and if the philosopher were to be judged by the standards of twentieth century science he would not appear very important. But it must be remembered that he was a pioneer who, by the force of his own ability created the serious study of natural history. The workers who had preceded him had dis-

covered relatively little; their works were mostly speculations and vague hypotheses. As Aristotle himself says, "I found no basis prepared; no models to copy . . . Mine is the first step, and therefore a small one, though worked out with much thought and hard labor. It must be looked at as a first step and judged with indulgence. You, my readers, or hearers of my lectures, if you think I have done as much as can be fairly required for an initiatory start, as compared with more advanced departments of theory, will acknowledge what I have achieved and pardon what I have left for others to accomplish."

In his two books, "Physics" and "Natural History of Animals" are set forth Aristotle's views on nature, and his remarkably accurate observations of both plants and animals. He distinguished about five hundred species of mammals, birds, and fishes, besides showing an extensive knowledge of corals and their allies, sponges, squids, and other marine animals. He understood the adaptation of animals and their parts to the needs placed upon them, and was familiar with the commoner principles of heredity. He considered life to be a function of the animal or plant exhibiting it, and not a separate entity, given out by some divine power, or mysterious force. Aristotle devised a hereditary chain, extending from the simplest animals of which he had knowledge to the highest, man. This chain was a very direct affair, not at all resembling the modern "evolutionary tree" in its various ramifications and irregulari-

ties. And yet, despite its deficiencies, this chain was the best conception of animal development and descent to be produced in more than twenty centuries.

Unfortunately, Aristotle saw nothing of value in the crude survival suggestion of Empedocles. He believed that there was a purpose, a continued striving after beauty, in all the variations of plants and animals, and allowed nothing whatever to what we, for lack of better knowledge, call "chance variation." He did, however, restate Empedocles' position in modern, scientific language in order that he might refute it the more ably. He argues strongly for his conception of purpose in evolution, saying, "It is argued that where all things happened as if they were made for some purpose, being aptly united by chance, these were preserved, but such as were not aptly made, these were lost and still perish." He then makes reference to the way which Empedocles used this conception to explain the non-existence of the mythical monsters of olden time, states again that nothing is produced by chance, and closes with the statement, "There is, therefore, a purpose in things which are produced by, and exist from, Nature."

Aristotle was far and away ahead of any other evolutionist of ancient times; indeed, had he turned his genius to the clarification and support of the survival hypothesis, instead of combating it, he might have been properly considered as the "Greek prophet of Darwinism." His teachings were opposed by the philosopher

Epicurus, who lived from 341 to 270 and was one of the most prominent figures of ancient rationalism. Epicurus did not believe in anything supernatural; he maintained that everything could be explained on a purely natural and mechanical basis. He excluded teleology, the doctrine of a conscious plan or purpose in evolution and nature from any place in true philosophy, thus taking an important stand in a struggle not yet settled. Unfortunately, Epicurus did not take the trouble to explain what his postulated natural causes were, or how they behaved. The agnostic may well say, with Elliot, that the organic world *seems* to be teleologically organized merely because it cannot be organized otherwise, but he must stand ready to show grounds for his statement.

After Epicurus we must pass from Greece to Rome. T. Lucretius Carus (99-55), more commonly known as Lucretius, revived the teachings of ancient Greek philosophers and united them with those of Epicurus, whose doctrines he made famous in the long poem, "De Rerum Natura." Lucretius maintained a purely mechanical, rationalistic view of nature, but ignored the valuable work of Aristotle. He revived Empedocles' hypothesis of survival, but confined its application to the mythical monsters of past ages—centaurs, chimeras, and so on. He believed in the spontaneous generation of life, speaking of mounds arising, "from which people sprang forth, for they had been nourished within." "In an analogous manner,"

says he, "these young earth-children were nourished by springs of milk."

Thus we see that Lucretius, although an excellent poet, was neither a good evolutionist nor a first-rate philosopher. In his abandonment of Aristotle he discarded the only phase of Greek thought which had come near to true conceptions of evolution, and in expounding the doctrine of spontaneous generation, he fostered an idea that was to prove of almost infinite harm to the evolution idea.

There was no one to carry on the work. Greece was no longer a great nation; her "philosophers" were mostly second-rate tutors. Rome produced no naturalists of note, Pliny, the greatest, being of small capacity for reliable observation. The Greeks had done much; they had asked questions and insofar as they were able, had given answers. They left the world face to face with the problem of natural causation, and their ideas endured as a basis for the work of future scientists and philosophers.

THE GREEK PERIODS[1]

GENERAL CONCEPTION OF NATURE:	DIVISIONS OF THE SCHOOLS
Mythological	The prehistoric traditions.
FIRST PERIOD: **Naturalistic**	I. **The Three Earliest Schools.** The Ionians: Thales (624 548), Anaximander (611-547), Anaximenes (588-524), Diogenes (440-). The Pythagoreans (580-430). The Eleatics. Xenophanes (576-480), Parmenides (544-).
Materialistic (Early)	II. **The Physicists.** Heraclitus (535-475), Empedocles (495-435), Democritus (450-), Anaxagoras (500-428).
SECOND PERIOD: **Teleological**	Socrates (470-399), Plato (427-347). Aristotle (384-322). The Post-Aristotelians, (so-called Peripatetics), including Theophrastus, Preaxagoras, Herophilus, and others.
THIRD PERIOD: **Materialistic** (Late)	A. I. **The Stoics.** II. **The Epicureans.** Epicurus (341-270). III. **The Sceptics.** B. I. **Eclecticism.** Galen (131-201 A. D.).

[1]Modified after Zeller and Osborn.

CHAPTER II.

FROM THE CHRISTIAN FATHERS TO KANT.

Inasmuch as almost the entire learning of Europe for several centuries was under the protection and rule of the church, it is important that we examine in some detail the fate of evolution at the hands of that organization.

The early church drew its teachings on the origin and development of life from two sources—the Book of Genesis, and the philosophies of Plato and Aristotle. The early Christian Fathers, or at least the more prominent of them, were very broad-minded in their interpretations of the "revelations" of the Bible. In the fourth century, Gregory of Nyassa began a natural interpretation of Genesis that was completed in that century, and the one following, by Augustine. Despite the plain statements of the direct, or "special" creation of all living things, to be found in Genesis, Augustine promulgated a very different doctrine. He believed that all development took place according to powers incorporated in matter by the Creator. Even the body of man himself fitted into this plan, and was therefore a product of divinely originated, but naturally accomplished development. Thus Augustine, as Moore says, "distinctly rejected Special Creation in favor of a doctrine which, without any violence to language, we may call a theory of Evolution."

It is particularly interesting to note, in these days when prominent men go about denouncing the doctrine of organic evolution as foul, repulsive, and contrary to the will of God, that the early churchmen were not troubled by such narrowness. Augustine not only gave up the orthodox statement of special creation; he modified the conception of time. To him the "days" of Genesis did not mean days of astronomy; they meant long and indeterminable periods of time. And it is particularly interesting to find him rebuking those who, ignorant of the principles underlying nature, seek to explain things according to the letter of the scriptures. "It is very disgraceful and mischievous," says he, "that a Christian speaking of such matters as being according to the Christian Scriptures should be heard by an unbeliever talking such nonsense that the unbeliever, perceiving him to be as wide from the mark as east from west, can hardly restrain himself from laughing."

Augustine was followed by some of the later church authorities, most notably Thomas Aquinas, who lived in the latter part of the thirteenth century. He did not add to the evolution idea, but rather expounded the ideas of Augustine. His importance was due to his high rank as a church authority, not to any ideas which he produced.

During the period between Augustine and Aquinas, however, science almost died out in Europe, and leadership in philosophy went into the hands of the Arabs. Between 813 and 833 the works of Aristotle were translated into Arabic, and they form the basis of the nat-

ural philosophies of the Arabians. Avicenna (980-1037) probably held a naturalistic theory of evolution, and is known to have been fundamentally modern in his conceptions of geology. During the tenth century scientific books were imported into Spain in considerable numbers, and the Spanish scientific movement culminated in the works of Avempace and Abubacer (Abn-Badja and Ibn-Tophail). The former held that there were strong relationships between men, animals, plants, and minerals, which made them into a closely united whole. Abubacer, a poet, believed in the spontaneous generation of life, and sketched in a highly imaginative fashion the development of human thought and civilization.

But the reactionary trend of church thought during the dark ages finally attacked and conquered Arabic progress. In 1209 the Church Provincial Council of Paris forbade the study of Arabic writers, and even declared against the reading of Aristotle's "Natural Philosophy." During the middle ages the progress backward was carried to an even greater degree. Men no longer cared to think, or to discover things; they preferred to be told what they should believe. This attitude was encouraged by the authorities of the church, who represented power, and who depended for their easy existence upon the servility of the people at large. Obedience to authority in intellectual as well as in political affairs was demanded of everyone, and by almost everyone was rendered as a matter of course. Those who by chance made real discoveries, and found that they contra-

dicted the established authorities, either refused to believe their own senses, or else feared to publish their information because of the almost certain prosecution that would follow. To believe blindly, without analysis or question, was considered right and proper; to seek knowledge for oneself was a crime that the medieval church, and her governmental allies, stood ever ready to punish.

But the autocratic enforcement of antiquated dogma, and the serf-like submission to authority, could not go on forever. A revolution came, even within the ranks of the theologians themselves. Giordano Bruno (1548-1600) revived the teachings of Aristotle, and combined them with theories, and combined them with ideas secured by omnivorous reading of Greek, Arabic, and Oriental writings. He undoubtedly had some conception of evolution, compares the intelligence of man and various of the lower animals, and recognizes a physical relationship between them. In geology he was essentially modern, arguing against the six thousand years of Bible chronology, and maintaining that conditions of his day were the same, fundamentally, as those during ancient periods of the earth's history—a doctrine which he probably borrowed from the Arabian, Avicenna.

Before considering others of the philosophers who became, during the sixteenth and seventeenth centuries, the sponsors of the evolution idea, we may well pause to glance at the general state of learning throughout Europe at the beginning of that period. Just as any idea is a product of the men who advocate it, so

is its development dependant upon the state of culture in the regions where it is being fostered. We must, therefore, consider the outstanding features of that environment in order to understand the true significance of the progress made along the line in which we are principally interested.

Universities in Europe were founded at the beginning of the twelfth century, following those established by the Arabs[1]. Oxford, the most noted university of England, was founded about a century later. For a long time after this, authority still held almost unchallenged sway. Naturalists were mainly compilers, repeating what had been said and done before them, and carefully avoiding anything new. But in the first half of the sixteenth century there sprang up, in the Italian university town of Padua, an important school of anatomy. In 1619 Harvey, an English physiologist, discovered[2] the circulation of blood, and applied the method of experimental study in zoology. This one piece of work was of far more importance than all of his contributions to physiology—of which he is usually considered the real founder—for it gave to scientists the one almost infallible method of securing information. In the latter half of the seventeenth century the study of microscopic organisms was begun, and the foundations of a logical classification of animals was laid by Ray.

[1]Osborn, "From the Greeks to Darwin," p. 86.
[2]This claim has at various times been disputed; Osborn, however, accepts it without question.

It was during these two centuries of progress that the basis of our modern methods of evolutionary investigation was laid. Oddly enough, this was done, not by the naturalists of the time, but by the natural philosophers, such as Bacon and Leibnitz. They found their source of inspiration in the Greek literature, especially the writings of Aristotle, incorporating material offered by the leading naturalists of their times. Probably their biggest contribution was in giving a proper direction to evolutionary research; they saw clearly that the important thing was not what had taken place among animals, but what changes and variations were going on under the very eyes of the investigators. By establishing the fact that evolution was nothing more than individual variations on a stupendously large scale, they brought variation into prominence and laid the foundation for Darwin's final triumph.

The second great achievement of the philosophers was their proof of the principle of natural causation. From Bacon, the earliest, to Kant, one of the last of these workers, this principle was the object of continued study and enthusiasm. Each of them believed that the world, and in fact, the universe was governed by natural causes instead of by the constant interference of a man-like Creator. Of course, this attitude was hailed as the rankest heterodoxy, and was under the ban of the church. Nevertheless, it prevailed, and has stood as a pillar of all natural philosophy of the present day.

Francis Bacon (1561-1626) was the first of

the natural philosophers of later-day Europe. He was familiar with the Greek science, but revolted strongly against the authority given it. So radical was his attitude that he went to wholly unjustifiable lengths in attacking the Greeks, calling them "children . . . prone to talking and incapable of generation." This enmity may partly explain Bacon's failure to put into practice the excellent ideas which he voiced in his epigrams, maxims, and aphorisms. He did, it is true, suggest the means whereby the natural causes of which he wrote might be discovered, but he did little investigation himself. Bacon was too near the reactionarism of the middle ages to consistently practice the inductive method of study, and as a result his work was not of lasting value.

The rebellion of Bacon in England was followed by that of Descartes in France, and Leibnitz in Germany. The latter philosopher did much to revive the teachings of Aristotle, likening the series of animals to a chain, each form representing a link. This conception, while good enough in Aristotle's time, was out of date when revived by Leibnitz, and did much to hamper a true interpretation of the evolutionary sequence. As we shall see more than once in this study, scientific ideas are not like statues or paintings, things of permanent and immutable value. An idea that was good, and valuable, a hundred years ago may be neither today, and its revival would work distinct harm to knowledge. The "faddism" against which enemies of science complain is

neither harmful nor iniquitous. An idea should be used to its utmost as long as it represents the height of our knowledge; then, when it has been replaced by new information which is an outgrowth of itself, should be relegated to the museum of scientific antiquities. An ancient, worn-out idea is just as harmful in science as it is in politics; the sooner it is done away with, the better for all concerned.

One of the most important, and at the same time, most puzzling, of the German natural philosophers was Emmanuel Kant (1724-1804). When thirty-one years of age Kant published a book entitled, "The General History of Nature and Theory of the Heavens," in which he attempted to harmonize the mechanical and teleological views of nature. He considered nature as being under the guidance of exclusively natural causes, a very advanced position when compared with the teological conceptions of other Germans. But in his critical work, "The Teological Faculty of Judgment," published in 1790, he abandoned his progressive views on causation, dividing nature into the 'inorganic,' in which natural causes hold good, and the 'organic,' in which the teleological principle prevails. He called to the support of this conception the discoveries of the then new science of paleontology, saying that the student of fossils must of necessity admit the existence of a careful, purposive organization throughout both the plant and animal kingdoms. That this assertion was unfounded is shown by the fact that not a few modern paleontologists are strong defenders of ration-

alism and the mechanistic conception of all life activities.

But in spite of the fact that Kant was so awed by the immensity of the problem of organic evolution that he declared it impossible of solution, he nevertheless declared himself in favor of the careful study of all evidence bearing upon it. In a most striking passage, quoted by Schultze and Osborn[1], he says:

"It is desirable to examine the great domain of organized beings by means of a methodical comparative anatomy, or order to discover whether we may not find in them something resembling a system, and that too in connection with their mode of generation, so that we may not be compelled to stope short with a mere consideration of forms as they are . . . and need not despair of gaining a full insight into this department of nature. The agreement of so many kinds of animals in a certain common plan of structure, which seems to be visible not only in their skeletons, but also in the arrangement of the other parts . . . gives us a ray of hope, though feeble, that here perhaps some results may be obtained by the application of the principle of the mechanism of Nature, without which, in fact, no science can exist. This analogy of forms strengthens the supposition that they have an actual blood relationship, due to derivation from a common parent; a supposition which is arrived at by observation of the graduated approximation of one class of animals to an-

[1]"From the Greeks to Darwin," pp. 101-102.

other." He goes on to say that there is an unbroken chain extending from man to the lowest animals, from animals to plants, and from plants to the inorganic matter of which the earth is composed. And yet the man who, in 1790, could give so clear an outline of the basic facts of evolution, was unable to believe that the sequence which he perceived would ever be understood! For in another passage he says:

"It is quite certain that we cannot become sufficiently acquainted with organized creatures and their hidden potentialities by aid of purely mechanical natural principles, much less can we explain them; and this is so certain, that we may boldly assert that it is absurd for man even to conceive such an idea, or to hope that a Newton may one day arise to make even the production of a blade of grass comprehensible, according to natural laws ordained by no intention; such an insight we must absolutely deny to man[1]."

Perhaps the production of a blade of grass is not yet thoroughly comprehensible to us, but certainly the essential steps leading to that production are now well known. Even at the time Kant wrote there lived a man who did much to render the explanation possible, and another who, though disbelieving in evolution of any sort, perfected the means by which evolutionists were to arrange and label the members of the animal and plant king-

[1]Quoted by Osborn, with the comment: "As Haeckel observes, Darwin rose up as Kant's Newton."

doms in order to make the study of them orderly and comprehensible. The great philosopher's passion for accuracy, although an unusual and most creditable character in an age noted for its loose thought and wild speculation, prevented him from seeing the great significance of his own work. When man is able to comprehend a problem, and to state it in clear, accurate language, the solution of that problem is almost assured. The final triumph may be years, or even centuries away, but its eventual coming need hardly be questioned.

CHAPTER III.

EVOLUTION AND THE SPECULATORS.

Henry Fairfield Osborn, noted evolutionist and paleontologist, divides the evolutionists of the seventeenth and eighteenth centuries into three groups—the natural philosophers, the speculative writers, and the great naturalists.

The speculative writers were a heterogenous group of men, partly philosophers, partly naturalists, and partly of various other professions, They were, in the main, untrained in accurate, inductive, scientific investigation, and depended upon the Greeks for most of their theory. They differed from the philosophers, some of whom we have already studied, in that their ideas were boldly advanced without any support of observation, or the slightest regard for scientific methods. Some of them were, for their day, immensely popular writers, and their

trashy books, filled with myriads of impossible "facts," undoubtedly did a great deal to block the progress of true evolutionary studies. Just as the public today does not distinguish between the would-be orator who talks of the "facts" of natural selection, and the true evolutionist, and ridicules both, so the public the eighteenth century linked the speculators with the sincere, hard-working naturalists, and declared the ideas of both to be foolish and blasphemous.

One of the most amusing of the speculators was Claude Duret, mayor of a small French town. In his "Histoire Admirable des Plantes," published in 1609, he described and illustrated a tree which he said was rare in France, but "frequently observed in Scotland[1]." From this tree, as pictured by the mayor, leaves are falling; on one side they reach water, and are slowly transformed into fishes; upon the other

[1]Osborn, on whose writings most of this chapter is based, comments that Scotland was "a country which the Mayor evidently considered so remote that his observation would probably not be gainsaid." This important fact, that the faker could not be contradicted, probably was responsible for many of the absurdities published. However, when we examine the general state of knowledge at that time, we are forced to admit that this is not the whole explanation. Without much question, many of these writers were at least partly serious, and actually believed the impossible tales which they printed, just as they believed they had seen witches and ghosts.

they strike dry land and change themselves into birds. Fathers Bonnami and Kircher were lovers of the same kind of natural history; the latter describes orchids which give birth to birds and tiny men. Other writers of the time described and figured such creatures as centaurs, sea-serpents, ship-swallowing devil-fish, unicorns, and so on, solemnly assuring the readers that they had seen, and sometimes even killed these creatures[1]. And all of this nonsense was greedily read and believed by people who refused to admit that one species might, in the course of thousands of years, change into something distinguishably different from the original form! One wonders if there has been a greater paradox in the world than a public which denied the existence of links between one species and another, yet believed in centaurs which were half man and half horse. Is it any wonder that, amid such an environment, science was almost stifled, and philosophy was largely a matter of deduction and imagination?

[1]The "Scientific Monthly" contains an interesting article on the history of scientific illustration, showing many of the remarkable pictures to be found in early works.

CHAPTER IV.

EVOLUTION AND THE GREAT NATURALISTS.

One of the outstanding figures of zoology, and for that matter, of all natural science is Carl von Linne, more commonly known as Carolus Linnaeus[1]. For many years naturalists had been struggling to establish a satisfactory system of naming and arranging the various forms of animals, plants and fossils, but without very definite or satisfactory results. Linnaeus devised a very simple method of naming organisms—one that is followed almost without modification even today. He chose Latin and ancient Greek as the languages in which the names should be cast, primarily because both of them were more or less familiar to all students of his day, and neither was an important language of modern times. The name itself was in two parts, one denoting the particular species, the other the group to which that species belonged. Thus the common chipping sparrow is *Spizella socialis*, just as a man is William Jones, or James Thompson. The only difference is that in Linnaeus' system of naming, the family name comes first; if the same plan were used in human names William Jones would become Jones William. This may sound awkward, but as a matter

[1]Carl von Linne was the greatest naturalist of eighteenth century Sweden. He lived from 1707 to 1778, and for many years was professor at the University of Upsala.

of fact it is extremely convenient, just as in a directory or telephone book it is convenient to have the family name given first.

In the early editions of Linnaeus' great work, the "Systema Naturae" (System of Nature), published from 1735 to 1751, the great naturalist stated specifically that he believed in the absolute fixity of species from the time of their creation, according to the literal interpretation of Genesis. But Linnaeus was too close a student to hold this idea for long, and in his edition of 1762 we find him expressing the opinion that many new species arose from the interbreeding of those originally created. However, he maintained that only species originated in this manner, and attributed the more general resemblances of animals and plants to similarities of form implanted by the Creator. Plainly, therefore, Linnaeus was at heart a believer in special creation in a very slightly restricted sense, and was by no means as progressive in this respect as the old Greek philosopher Aristotle.

Foremost among the contemporaries of Linnaeus was George Buffon, (1707-1788), the Frenchman whom Osborn has called the "naturalist founder of the modern applied form of the evolutionary theory." During his early work Buffon held essentially the same views as his contemporary, Linnaeus, stating that the species of animals were separated by a gap which could not be bridged, and that every where were evidences of "the Creator, dictating his simple but beautiful laws and impress-

ing upon each species its immutable characters."

As early as 1755, however, Buffon found that his studies in comparative anatomy placed many difficulties in the way of these "simple but beautiful laws" and "immutable characters." He calls attention to the fact that the pig is plainly the "compound of other animals," possessing many parts for which it has no use, and concludes that "Nature is far from subjecting herself to final causes in the formation of her creatures," and that by continually searching for such causes men "deprive philosophy of its true character, and misrepresent its object, which consists in the knowledge of the 'how' of things." In 1761 he acknowledged a belief in the frequent modification of species, but believed that some animals were much more subject to variation than others. He understood the struggle for existence, with its consequent elimination of the species least capable of living under unfavorable circumstances, and stated it very clearly.

One of the most interesting portions of Buffon's evolutionary philosophy was his belief that external conditions could directly modify the structure of animals and plants, and that these modifications were hereditary. This was, in essence, the theory of transmission of acquired characters—a theory which was to be greatly elaborated by one of Buffon's successors, and which was to cause trouble among evolutionists for many decades. Buffon applied it particularly to the animals of the western hem-

isphere, showing how they were changed by climate, food, etc., so that eventually animals coming from the eastern hemisphere to the western[1] would become new species. In this connection he emphasizes the fact, also pointed out by Kant, that man must study the changes taking place in his own period in order to understand those which has been accomplished in the past, and might be accomplished in the future.

Even at the time when he believed most thoroughly in evolution and variation, Buffon was troubled by the Bible account of creation, and wavered between the two. Some time after 1766 he abandoned his advanced stand on evolution, and concluded that species were neither static nor changeable, but instead that "specific types could assume a great variety of forms[2]," and that no definite assertions might be made regarding the origin of any particular animal or plant.

One cannot but wonder what was the cause for Buffon's confusion and changes of attitude. From special creationist to radical evolutionist, and then to conservative occupying a position

[1]In Buffon's day the Americas were still the "New World," and it was customary with naturalists of the time to consider it new, not only in discovery, but in its plant and animal inhabitants. For them, the animals of America came from the Old World, just as did its white settlers; the idea of opposite migrations was quite unheard of. How different this conception was from the actual state of affairs can be seen by reference to such books as Osborn's "Age of Mammals."

[2]Osborn, op. cit. p. 138.

halfway between was a remarkable mental evolution to be covered in the space of less than sixty years. What was the cause of it?

The answer to this question is not a difficult one. Buffon was a pioneer, and not an overly courageous one. He was staggered by the immensity of the problem which he was trying to solve, and at the same time, fettered by the orthodox ideas of his day. And back of those ideas, as Buffon well knew, there was power—power of the church, of society, and of the scientific world. And neither the church, society, nor science was ready to accept the doctrine of descent, of organic evolution. Linnaeus, as we have seen, was easily the greatest and most influential zoologist of his day, and was at the same time a strong anti-evolutionist. His influence was so great that Buffon could hardly have escaped it, and this probably added to the difficulties of the vacillating evolutionist.

And so, when we considered the difficulties under which Buffon worked, we are not surprised that he found it hard to discover what his ideas on evolution should finally be. He was evidently no hero, willing to become a martyr for science, nor yet a dogmatist, willing to lay his own ideas down as law. Instead of ridiculing him for his indecision, therefore, we should sympathize with him because of his difficulties. Probably few of us would say or write very revolutionary things if we were loaded down with half-shed orthodoxy, and threatened by social and scientific

ostracism in case we made a departure from the well beaten path.

The next important figure in evolution is Erasmus Darwin, grandfather of the great Charles Darwin. He was a country physician, a poet, and a very accurate naturalist, but unfortunately buried his ideas in volumes of verse and of combined medicine and philosophy. He believed in the spontaneous origin of the lower animals, but maintained that all of the higher forms were products of natural reproduction. The transition from water-to-land-dwelling animals he illustrated, not by fanciful creations, but by the classic example of the development of the frog, which begins life as a legless tadpole, and ends it as an animal incapable of breathing under water.

To man Dr. Darwin gave much attention, devoting a whole canto to the human hand—"The hand, first gift of Heaven!"—and outlining the development of man's various faculties. Farther on he describes the struggle for existence in lines which remind one of Tennyson's description of nature, except that they lack Tennyson's inevitable syrupiness. Evidently, however, Darwin fails to connect this struggle with its obvious result, the survival of the fittest.

Dr. Darwin's theory of evolution differed from that of Buffon in at least one important respect. Nowhere does he stress the direct influence of environment in the production of variations; on the contrary, he maintained that modifications spring from the reactions of the organism. In this he clearly stated the

theory which is generally known as Lamarck's version of the theory of the transmission of acquired characters. In fact, he carried his ideas much farther than did Lamarck, attributing to plants the attribute of sendibility, and supposed their evolution to be due to their own efforts toward the development of certain characters. Adaptations, which Aristotle had believed to be caused by a definite plan, Dr. Darwin interpreted in a purely naturalistic manner. The Creator had, at the beginning, endowed organisms with the power to change and develop, and that power was handed down from one generation to another until it was possessed by every animal and plant. This power was the cause of all variation, adaptation, and evolution, and there was no further divine interference. Dr. Darwin did not see any great, all-encompassing plan of improvement, such as is postulated by the teleologists of today; to him everything was the logical and necessary outcome of the original powers of living things. In this, as we shall see, he believed essentially as do modern evolutionists who do not see in the laws of the universe any necessity for abandoning religion, but who at the same time do not believe in a highly personal god who, as one theologian expressed it recently, "works out His divine will through the processes of evolution."

Dr. Darwin was author of two other distinctly modern ideas, among the most important of his entire work. The first of these is that all living things are descended from a single original living mass, or "filament"—that every liv-

ing thing on the earth is related to every other living thing. The second is that the process of evolution is almost inconceivably slow, and that millions upon millions of years have been necessary for it. The first idea, while quite conceivably true, can never be proved definitely, but the second has been demonstrated over and over again. Just how many millions we shall allow is, of course, undetermined; some authorities demand sixty; others say that eight hundred is a figure none too large. In this series of books the larger figure is adopted, not because we are certain that it is right, but because it seems to fit more closely with the facts of evolution than do the smaller ones. How fully Dr. Darwin was a prophet of modern scientific chronology we are just beginning to recognize.

The leadership in evolution, which for a time had gone to England, was soon given back to France. The new champion of the theory was Jean Baptiste Lamarck (1744-1829), one of the most pathetic figures in the entire history of zoology. He was a brilliant man, and a skilled zoologist, but because he was courageous, blind, and desperately poor, he suffered little less than martyrdom throughout much of his life, and was given but scant attention by his contemporaries. Baron Cuvier, rich, talented, and a member of the elite of the nation, dominated French zoology. He was a desperate reactionary, holding out for a literal acceptance of the Bible account of special creation, and ridiculed not only the theories of Lamarck, but the whole conception

of evolution. For years he blocked the progress along all lines but his own restricted field of anatomy, and waged bitter warfare on anyone who dared to oppose him. And so the blind Lamarck lived in poverty and obscurity, neglected by both scientists and those who knew nothing of zoology. And through this he stood faithfully by the ideas which he believed but was too poor and unknown to defend.

Lamarck first held to the old teaching that species were fixed, and could neither change nor be changed. But as he learned more his views changed, and in 1809 he published a book stating his interpretation of evolution. One of his principal ideas was that the effects of the use or disuse of any part of the body may be passed on from parent to children until they finally become parts of the animal's make-up. It is well known that an arm that is never used becomes weak; that a muscle which is constantly at work becomes strong and large. Lamarck supposed that this increase or decrease in size could be inherited, and thus races with short, thin arms, or heavy powerful muscles could be developed. This is the "theory of inheritance of acquired characteristics" again, first formulated by Erasmus Darwin. Just how much there is to this theory no one has been able to say; some believe it to be worthless while others, particularly those who study fossil animals, think that it possesses a certain amount of truth.

Lamarck was, as we have said, a conscientious scientist, and made use of his own accurate

observations insofar as this was possible. But when he became blind, dictating his books to his daughter in order to get them written, observation was clearly out of the question. In its stead the great naturalist was forced to rely upon the reports of other observers, and those reports were none too reliable. The obvious weakness of some of his second-hand facts reacted very unfavorably upon the whole work of Lamarck, and gave his opponents abundant weapons for their attacks upon his opinions.

But in spite of these handicaps, Lamarck did a very important work. He not only stated his own position very clearly, marshalling such facts as were at his disposal to its support; he devised a branching system of animal descent which approximated the modern "evolutionary tree" and represented far more truly than did the Aristotelian chain the true state of things. He argued strongly and clearly against the fallacious doctrine of special creations and numerous geologic catastrophes which, supposedly, annihilated all of the life on earth at the particular times of their occurrence and made a long series of new creations necessary.

Perhaps the greatest of all Lamarck's achievements was his clear statements of the problems of evolution. As one writer has said, he asked every one of the big, important questions which later evolutionists have had to answer, and by the clear phrasing of his questions, made the answers thereto the more easy.

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In all France there was only one man who

was willing to champion this blind naturalist in his stand for evolution. Geoffrey St.-Hilaire was at first a follower of Buffon, but he later became convinced of the value of Lamarck's work, and even went so far in his belief as to champion Lamarck in a public debate with the great Cuvier. Despite the fact that the debate brought a certain fame to St.-Hilaire, he was judged the loser, and the affair was hailed as a great and conclusive victory for those who upheld the theory of special creation.

Although St.-Hilaire believed in the truth of organic evolution, he did not wholly agree with Lamarck. He supposed that environment —that is, surrounding conditions—determined the changes that took place in animals, and preceded some of the most modern of evolutionists by teaching that one species might arise suddenly from an earlier one, without any intermediate forms. As a result of these sudden changes, it was, said St.-Hilaire, often unnecessary to produce the "missing links" over which adverse critics made such a to-do. It was also unnecessary to show why variations would not be wiped out before they were firmly established. According to his hypothesis, each new form was complete, and no amount of normal interbreeding with other forms would produce fertile hybrids between the two.

We now come to one of the most interesting, and most remarkable of evolutionists. Johann Wolfgang Goethe (1749-1832) was an anatomist, a philosopher, and a great poet, and thus brought to the problem of organic evolution a

breadth of vision equalled by but few of the workers who preceded him. As Osborn states:

"The brilliant early achievements of Goethe in science afford another illustration of the union of imagination and powers of observation as the essential characteristics of the naturalist. When he took his journey into Italy, and the poetic instinct began to predominate over the scientific, science lost a disciple who would have ranked among the very highest, if not the highest. Of this time Goethe says: 'I have abandoned my master Loder for my friend Schiller, and Linnaeus for Shakespeare.' Yet Goethe, in the midst of poetry, never lost his passion for scientific studies. He seems to have felt instinctively that what contemporary science needed was not only observation, but generalization."[1]

Goethe derived much of his inspiration from Buffon and the German natural philosophers. Unfortunately he never discovered the works of Lamarck, although he anticipated that scientist in some of his work with plants. There can be little doubt that, had Goethe discovered the "Philosophie Zoologique," he would have accepted its principal doctrine, and would have proclaimed them with a vigor that would have overcome even the antagonism of Cuvier. As

[1]Op. cit., pp. 181-182. The need of which Dr. Osborn speaks was not by any means confined to science of Goethe's time. The great characteristic of modern paleontology, for example, is observation without either generalization or philosophy. It is for this reason that the science of fossils has yielded relatively meagre data on evolution.

it was, he confined his theory to the idea of the "unity of type," making it the chief basis for his conception of evolution. In his own words, this theory enabled him to "assert, without hesitation, that all the more perfect organic natures, such as fishes, amphibious animals, birds, mammals, and man at the head of the list, were all formed upon one original type, which varies only more or less in parts which are none the less permanent, and which still daily changes and modifies its form by propagation."

Akin to Goethe, in some respects, was Gottfried Treviranus (1776-1837), a German naturalist who was a contemporary of St.-Hilaire, Goethe, and Lamarck. Like the German natural philosophers, he considered life as the result of chemical and mechanical processes, and protested whole-heartedly against purely speculative work, calling it "dreams and visions." At the same time, he complained that most of botany and zoology was made up of dry registers of names and that the work of many naturalists consisted of the "spirit killing * * * reading and writing of compilations." Treviranus believed that it was quite within the abilities of man to discover the basic philosophy of nature, largely by the use of working hypotheses as a means of aiding the investigator in attaining the actual facts.

In view of Treviranus' modern stand on the study of animal life, and the interpretation of ascertained facts, we might well expect him to show an equal modernity in his conception

of evolution. But in this we are to be disappointed. As soon as he departed from his principles of biology, and attempted to apply those principles to the development of animal life, Treviranus became victim to those same "dreams and visions" against which he protested so strongly. He depended very largely upon the work of Buffon, and believed that modification of form was due entirely to environment. He revived the ancient doctrine of spontaneous generation of living things, or abiogenesis, stating his belief very clearly.

All of this shows that Treviranus, although an ardent believer in evolution, added very little to the idea. In his ideas of the factors of volution he did not advance beyond Buffon; in his ideas of descent he was less clear and accurate than his contemporary, Lamarck. But in his more general work, particularly in defining and organizing the science of biology, he rendered great service to future zoologists and evolutionists. And such service, slight though it was, was of value. During the early part of the nineteenth century the doctrine of evolution needed all the support that could be given it, and even a mistaken scientist was a valuable defender of a struggling cause.

Thus for more than two thousand years the theory of organic evolution had been growing. Philosophers, country doctors, poets, and naturalists had contributed their share to its volume, its character, and its support. But as yet is was little more than an idea in the rough, waiting for some one to refine it, to put

it into clear and unmistakable language, and to back it up by evidence secured directly from studies made on living animals and plants. It might have been compared to a piece of ——— waiting for someone to forge it into a key— a key that would open the doors of conventional thought and old-fashioned restriction, and thereby give an insight into life and life's history that would revolutionize human thought, and help in a better understanding between man and man, and man and beast.

CHAPTER V.

DARWIN AND THE TRIUMPH OF EVOLUTION

The outstanding figure of the entire history of evolution is Charles Darwin. Whether or not be deserves all of the prominence that has been given him is a question—a question that probably must be answered in the negative. We are very apt to lionize the victor while we ignore those who made the victory possible, whether it be won in science, politics, or warfare. Among certain circles today there is an undeniable tendency to over-praise Darwin; to talk and think as though he were the first and the last truly great evolutionist. It is becoming with Darwin as Harris found it with Shakespeare: "He is like the Old-Man-of-the-

Sea on the shoulders of our youth; he has become an obsession to the critic, a weapon to the pedant, a nuisance to the man of genius." If we substitute 'popularizer' for 'critic,' Harris' sentence will apply to Darwin without further modification. There is a popular misconception that a great and successful scientist must of necessity be a man of great genius; nothing of the sort is true. Take the average "authority" away from his specialty, and he is a very commonplace individual; take him with it, and he is often little more than a remarkably durable and precise human machine.

Neither biographers nor critics have shown us any good reasons for considering Charles Darwin an exceptionally great man. He was a highly successful scientist, but at the same time he was aided to success by the condition of science during the eighteenth and nineteenth centuries, and his personal fortune. In this connection it will be worth our while to examine the opinions of Carlyle, as reported by Frank Harris. The two were discussing notables of the century, and Harris brought up the name of Darwin. Carlyle described the two brothers as "solid, healthy[1] men, not greatly gifted, but honest and careful and hardworking * * *" and speaking of a conversation with Charles Darwin after his return from the "Beagle" voyage, said: "I saw in him then qualities I had hardly done justice to before: a patient clear-mindedness, fairness too,

[1]This was not true of the naturalist in later life, when/he was for years a semi-invalid.

and, above all, an allegiance to facts, just as facts, which was most pathetic to me; it was so instinctive, determined, even desperate, a sort of belief in its way, an English belief, that the facts must lead you right if you only followed them honestly, a poor, groping, blind faith—all that seems possible to us in these days of flatulent unbelief and piggish unconcern for everything except swill and straw."[2]

We need not, like Carlyle, abuse this "allegiance to facts"; it is the foundation-stone of all reliable scientific work, and the scientist who abandons it is sure to bring disaster to himself and his work. And yet, to maintain that fact-hunting is, of necessity, a mark of genius is absurd.

It is largely the qualities that prevent us from ranking Darwin as a genius that establish his eminence as a research scientist. He is great not for his ideas, for they had been worked out before him, but for the clearness with which he stated his conclusions, and the wealth of proof which he brought to their defence. The earliest evolutionists tried to solve their problems by deduction, making the theory first, and searching for the facts afterward. Darwin's method was just the opposite. As he himself says, he searched for fact after fact, at the same time straining to keep all thought of theory from his mind. Finally, when he had ascertained how things actually were, and had arranged his information, he set forth to formulate a theory that might accord fully with

[2]"Contemporary Portraits," pp. 12-13.

what he knew to be the truth. He took the ancient, indefinite idea of evolution and welded it into an organized theory, and armed it with an array of facts that made it irresistible. While some of Darwin's beliefs have failed to show the importance he assigned them, and others of them are very probably errors, there are few indeed who seriously, from the standpoint of science, care to question the conception that all living things have developed from earlier living things of simpler or more primitive character. His careful, painstaking work gained for his ideas a world wide acceptance among thinking men, and made Charles Darwin one of the greatest figures in the history of science.

The story of Darwin's life is a story of long, careful study and preparation, of rapid publication of his discoveries when he set out to write them, and finally of triumph over those who opposed him. He was born on the twelfth of February, 1809, the same day that brought the world Abraham Lincoln. Someone has said that on that day the world's greatest liberators were born—in America the one who would free the bodies of men from bondage; in England the man who would free their minds from a no less real slavery to custom, power, and worn-out dogma.

When he was sixteen years old, Darwin went to Edinburgh to study medicine. But he was already a rebel against dryness and dead academic thought, and wrote home that the lectures in anatomy were quite as dry as was the

lecturer himself. After two years of medicine he gave up his work at Edinburgh, and went to Cambridge to become a preacher. But while studying for the ministry the young Darwin spent a great deal of his time with nature, and acquired something of a reputation as a naturalist. When, in 1831, he was offered the chance to make a five years' trip around the world as naturalist on the exploring ship "Beagle" he did not delay long in accepting. The things seen, and the facts learned on that long voyage probably had more to do with making Darwin a great naturalist than any other single phase of his life. On his return to England the young man set about writing up the results of his studies while on his trip, and put into this book most of the arguments which he had to give in favor of evolution. In 1856 he sent this report to Sir Joseph Hooker, then the leading authority on plants in England, and finally in 1859 published his great book, "The Origin of Species." This was the first concise statement of a theory of evolution, backed up by actual evidence, and it created a furore both in Europe and America. Some scientists eagerly took up with Darwin's ideas, seeing in them the explanation of facts that they had long been unable to understand. Others, lacking in breadth of knowledge, or unwilling to give up old beliefs, fought bitterly against evolution. The controversy involved not only scientists, but the churchmen, and was a leading feature in newspapers, magazines, and

books. "The Origin of Species" ran into many editions, and was translated into several languages. Darwin found himself a center of interest for the world, and his theory a cause of heated argument for all who cared to talk or write about it.

How revolutionary Darwin's work was, and how unwillingly he himself came to the conclusion that organic evolution was an undeniable truth, it is hard for us to understand. For most of us, some at least, of the essential facts of evolution are every-day knowledge; we look upon the anti-evolutionist as a strange anachronism—a hang-over from a past age. But in Darwin's day conditions were very different. Thus we find him, in a letter written in 1844 to the great botanist Hooker, saying:

"I have been . . . engaged in a very presumptuous work, and I know no one individual who would not say a very foolish one. I was so struck with the distribution of the Galapagos organisms, etc., and with the character of the American fossil mammifers[1], etc., that I determined to collect, blindly, every sort of fact, which could bear in any way on what are species. . . . At last, gleams of light have come, and I am almost convinced (quite contrary to the opinion that I started with) that species are not (it is like confessing a murder) immutable. Heaven forfend me from Lamarck

[1]"Mammifers" = mammals; that is, animals which suckle their young.

nonsense[2] of a 'tendency to progression,' 'adaptations from the slow willing of animals', etc.! But the conclusions I am led to are not widely different from his; though the means of change are wholly so." This last statement, as we shall see by reference to the "Origin of Species" was not wholly true.

Another glimpse at the state of affairs in 1859 and the immediately succeeding years may be found in Darwin's anxiety to convince Hooker, Lyell, and Huxley that species were variable and changeable, and his rejoicing when Huxley wrote out his very guarded acceptance of the Darwinian version of organic evolution. We find it hard to conceive of Huxley, the "war-horse of Darwinism" reluctantly agreeing to most of Darwin's points, but at the same time voicing strong objections to others. And yet these very objections of Huxley's, made in 1859, were in 1921 paraded before an audience at one of the country's most famous universities as evidence against the truth of organic evolution!

In France, even more than in England, the "Origin of Species" was held in disapproval. A translation of the book was offered to a

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[2]Darwin seemed unable to speak of Lamarck without contempt or derision. Certainly he was not familiar with Lamarck's writings in the French, and attributed to that naturalist certain erroneous ideas for which he was not responsible. Also, it would seem that Darwin failed to make allowances for Lamarck's insuperable handicaps, and his position as a pioneer, and therefore adopted an attitude of unjustified antagonism.

noted publisher of Paris, and was unceremoniously refused. The country which had praised Cuvier, and ridiculed Lamarck and St.-Hilaire was not going to receive willingly the contributions of an iconoclastic Englishman. We are not surprised to find Darwin depressed by the European reception of his theories, and writing to Huxley: "Do you know of any good and speculative foreigners to whom it would be worth while to send my book?"

But what was this "new" theory of evolution that so aroused the world? What were its characteristics, and how did if differ from the theories of Aristotle, Kant, Buffon, and Charles Darwin's own grandfather, Dr. Erasmus Darwin?

The theory of evolution set forth in the "Origin of Species" contained three principal factors: (1) the constant variation of animals and plants, (2) the struggle for existence, and (3) the natural selection of those organisms which possess variations which are of value to them in their attempt to keep alive.

The idea of variation was based upon simple observation. Dr. Herbert Walter has said that "variation is the most constant thing in nature," and paradoxical as that may seem, it is nevertheless true. No man looks exactly like another man, no tree exactly like another tree, no shell exactly like another shell. The Japanese artists appreciate this variation, and make use of their knowledge in painting, which is one of the reasons why their art is not readily appreciated by the occidental who is much in-

clined to "lump" things. No Japanese artist would think of painting two dogs, or two streams, or two houses that resembled each other in every respect, for he knows that every thing in the universe, whether it be alive or dead, organic or inorganic, differs from every other thing in the universe. Sometimes the difference is easily seen, as that between a shark and a goldfish, or a Negro and a Scandinavian or Teuton. At others it is almost indistinguishable, and can be discovered only by the most accurate micrometer, or the most precise chemical analysis. But always the difference exists, the variation is present, and this fact is the basis for Darwin's belief in the inborn necessity for all living things to vary.

The second factor, that of a struggle for existence, was suggested to Darwin by a reading of Malthus' classic paper on population. All creatures normally tend to increase in numbers. Mating fish produce millions of eggs in a season; chickens rear nestfulls of young; rabbits and guinea-pigs produce litter after litter of young from the matings of two parents—everywhere, both in nature and in domestication, living things seem to be on the increase. And yet we have no evidence that (excluding the rather doubtful influence of man) there are more animals on earth today than there were half a million years ago; the probabilities are that there are fewer. Clearly, therefore, some process is at work which prevents the seeming increase from taking place.

In order to understand something of the complexity of this process, let us select a specific example. Among marine animals, the oysters are remarkable for the immense numbers of eggs which they produce—the average for the American oyster is probably about 16,000,000. If all the progeny of a single oyster were to live and reproduce, and their progeny were to do likewise, and so on until there were great-great-grandchildren, the total number of oysters that were descendants of the original pair would be about 66,000,000,000,000,000,000,000,000,000,000 and their shells would make a mass eight times as great as the earth.

Now it is quite obvious that the earth cannot hold, and cover with water, a mass of oyster shells eight times as great as itself; the oceans, if they were spread evenly over the surface (which they never were, and never can be), would accommodate but a few of the great horde. Neither do those same oceans contain enough food to satisfy, or begin to satisfy, the needs of these theoretical descendants of a single oyster. Clearly, therefore, space and food alone are enough to prevent the undue multiplication of creatures upon the earth.

But there are factors other than space and food which aid in accomplishing the result. There are water conditions, animal enemies such as the starfish, and a host of other means by which the population of oysters is kept down. And even if it were to increase greatly, the numbers of starfish would at the same time increase, and simultaneously set about decreas-

ing the numbers of the oysters, which decrease would in turn cut down the numbers of the starfish, and so on. Thus we see that the maximum abundance of an organism is arbitrarily set by the conditions under which that organism lives. It may attain the limit set for it, but beyond that it may go only temporarily. Then the surplus dies from starvation, crowding, animal and plant enemies, and a thousand other of the factors which constantly work in the constant warfare of nature, the never-ending "struggle for existence."

The third factor of Darwinian evolution, that of natural selection, is based upon the other two. Darwin supposed that the individuals of a species, or variety, exhibited variations for two reasons: because it was part of their very nature to do so, and because the conditions of their environment forced them. In the course of this constant change there would, of necessity, be some modifications that were of value to their possessors, while others would appear which were of more or less definite harm. In the course of the struggle for existence, those creatures which possessed helpful variations would naturally possess a certain advantage over those which lacked it or which exhibited variations which were of harmful nature. Thus in a cold, snowy climate, that animal which developed a white coat would be much safer from detection than his companions which might have fur of a dark hue, either in approaching his prey, or in escaping his pursuers. The ultimate outcome of this would be

that the white animal would populate the region, while his colored brethren would soon become extinct. The same principle, Darwin thought, applied to mental advantages; the more skillful mind triumphed over the less; the quick-witted animal lived at the expense of the clumsy-witted one. Throughout the earth, those animals most capable of living lived, brought forth young, and thus perpetuated their capabilities, both mental and physical. This process quite plainly helped in the development of man, and in his progress, but singularly enough, within this ranks today it does not operate. Great mental capacity is not today the most important survival factor among humanity. As the archeologist Keith has pointed out a great philosopher or artist may lead a life of misery, want, and despair, and leave no descendants, while a thoughtless, happy Burman will live out his days believing that the earth is flat and Buddha an all-powerful god, but will leave behind him a large and rapidly multiplying family.

During the years just prior to the appearance of the "Origin," Darwin had an almost complete confidence in the power of natural selection to account for all the phenomena of evolution. Even in the year when that work appeared, he wrote Lyell: "Grant a simple archetypal creature, like the Mud-fish or Lepidosiren, with five senses and some vestige of mind, and *I believe Natural Selection will account for the production of every vertebrate animal.*" In publication, however, he was more

cautious, saying, "I am convinced that Natural Selection has been the main, but not the exclusive means of modification."

From his extreme position on the effective ability of natural selection to seize upon a variation and so foster it that a new species would appear, Darwin slowly but not unwillingly receded. Ten years after the first publication of the Darwinian theory[1], he admitted that variations might not have been so supremely important as he supposed; in 1878 he believed in the direct action of environment in producing variations, as did Buffon; in 1880 he adopted Lamarck's theory of the use and disuse of parts. In 1881, in the "Descent of Man," Darwin lays much stress upon sexual selection, the idea that members of one sex rendered themselves particularly attractive in order to capture the attentions of their would-be mates. This, however, is really a subdivision of the natural selection idea—in the general reliability of which the famous evolutionist still believed.

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As we have said, in the estimate of Darwin's general environment, the world of the middle nineteenth century did not welcome the new prophet of natural law in the natural world. Many scientists accepted Darwinism, or at least, the principle of evolution, without reserve; others made reservations; most of the

[1]"Darwinism," or "The Darwinian Theory" refers to the theory of natural selection, and the sub-theory of sexual selection, not to the theory or concept of organic evolution.

"intelligentsia" declared it to be without the slightest element of truth. The public in general, and especially the church, clung to the old, valueless doctrine of a multitude of special creations by an omnipotent deity, apparently forgetting that the greatest of the church fathers, Aquinas and Augustine, had been prominent evolutionists in their day. There arose about Darwin's theories a storm of argument that lasted for many years, and involved scientists, theologians, philosophers, and laymen thorughout the world.

Darwin, although an excellent and self-confident scientist, was modest, retiring, and greatly hampered by ill-health contracted during his "Beagle" voyage. He was forced to leave the work of publicly defending his theories to other men, the most noted of whom was Thomas Henry Huxley, the "Bull dog of Evolution." Huxley was an accomplished scientist, a powerful speaker, and one of the finest of European writers of science for the every-day man. He wrote, taught, and lectured in defense of the evolution theory; after a long, hard day at the university, he would spend the evening lecturing before crowds of workingmen from London's factories, telling them how one species came from another, and how a single-celled creature developed into a complex animal with hundreds of millions of cells in its body, at the same time reconstructing during its growth the entire evolutionary history of its kind. It was largely because of the lectures and magazine articles of this tireless scientist, who believed in the truth of

evolution, and enjoyed the task of fighting for his beliefs, that Darwin achieved so early an almost complete victory over the scientists who opposed him. Of course, the triumph was not all-embracing; there are still a few people who follow the natural sciences and yet refuse to believe that one species can arise, either by natural selection or by some other means. from another species without the interference of a deity. And the public at large, particularly that portion of it which lives far away from museums, zoological gardens, and centers where illustrated talks on natural science are regularly given, still believes in the theory of special creation. But that belief neither signifies defeat for Darwin and his followers, nor casts doubt upon the essential truth of their ideas; it simply means that the theory of evolution is still relatively young, and that popular education is in its infancy.

CHAPTER VI

THE POST-DARWINIANS: DEVRIES AND THE MUTATION THEORY.

The period between 1860 and 1900 was occupied largely by elaborations of the Darwinian conception of evolution, and arguments as to whether or not organic descent was a fact. In those four decades there were many famous workers—Alfred Russell Wallace, co-discoverer with Darwin of the theory of selection; Weismann and Haeckel, Germany's

great evolutionists; the philosopher, Spencer; Cope, the American paleontologist, and Huxley, the English champion of scientific rationalism—these, and a host of others spent their lives in demonstrating the workings of evolution. But unfortunately, the opposition which they encountered forced them to write and work largely along lines of argument and thus much of their work was fruitless so far as the discovery of new principles is concerned.

During this same period the doctrine of evolution suffered much from over-enthusiasm on the part of some of its defenders. Even Wallace overdid the hypothesis of sexual selection, and the kindred hypotheses of concealing and protective coloration. Naturalists sought to explain every coloring of animals and plants as being of some value to them, and therefore the real cause of the existence of the species; not a few carried the idea of value in sexual differences, such as those between the male and female peacock, to a similar extreme. But in spite of the inaccuracies which they published, these enthusiasts did far more good than harm, for they aided greatly in securing popular support for the main theory.

It was toward the beginning of this century that evolutionary studies received another great stimulus. Professor Hugo de Vries, a Dutch botanist of considerable note, proposed what he called the "mutation theory" as a substitute for Darwin's conception of "natural selection." He began his studies by attempting to produce by careful selection a variety

of buttercup which should contain in its flower more than the normal number of petals. He actually achieved the desired increase, but it was far from a stable condition; while some of the flowers possessed eight, nine, or ten petals, and a few as high as thirty-one, many of them possessed the original number, five. When selection was abandoned there appeared at once a general retrogression toward the primitive state, and this fact caused de Vries to conclude that selection alone was not enough to cause the formation of a new species of plant or animal[1]. Instead, he concluded that when a change of permanent value took place in a plant or animal it was something entirely different from the constant variations on which Darwin and his followers relied; it was a discontinuous variation—a 'sport,' the florist or gardener would call it—to which de Vries applied the new name mutation. Mutation, he believed, involved a very definite change in the reproductive cells of the organism—a change which had absolutely no relation to the environment. They arose from conditions within the plant and animal, and might or might not affect it favorably. Those mutations which were not beneficial would be eliminated by selection; those which were of value to the creature would probably be preserved. Thus, in de Vries' mind evolution was a process due primarily to internal causes, its course being merely guided by en-

[1]This conclusion was probably unjustified; his observation covered too short a period to mean a great deal.

vironment, which selected those mutations capable of surviving.

Without question, de Vries had a real basis for his theory. Mutations do take place among both wild and domestic creatures; thus among the dandelions there constantly appear special types which breed true and are, as Castle has called them, "little species within the dandelion species." Similar mutations are well known in peas, beans, evening primroses, and such domestic animals as the sheep. Clearly, therefore, species do arise as de Vries stated; the question is, is this the only way in which they arise?

This problem was raised little more than twenty years ago—a period far too short to allow for the settling of a question that is merely another statement of the problem that has puzzled scientists and philosophers for more than twenty centuries.

There is, however, excellent reason for believing that the conceptions of both de Vries and Darwin are true; that neither of them excludes the other from operation. Thus in the famous chalk formation of England there may be found an evolutionary chain of sea-urchina which, according to the general concensus of opinion, represent true Darwinian evolution. As N. C. Macnamara says, "They are first found in their shelled, sparsely ornamented forms, from which spring, as we ascend the zone, all the other species of the genus. The progression is unbroken and minute in the last degree. We can connect together into continuous series each minute variation and

each species of graduation of structure so insensible that not a link in the chain of evidence is wanting."

On the other hand, the writer has recently completed a microscopic study of a group of ancient lamp-shells—animals which looked somewhat like molluscs, but which were very different internally—with altogether different results. The particular changes involved were minor matters of surface markings, which could have had no conceivable importance to the animals. Selection, therefore, may be virtually ruled out; indeed, many of the different forms lived close together, with apparently equal success. But in the small markings on the shells there appear, as one follows the series from bottom to top, very decided changes, and those changes are, in some cases, abrupt and complete.

In others the variations are very small—indeed they could be distinguished only with the microscope—but so far as could be told, were distinct. This, therefore, points to a course of evolution that was clearly a matter of mutation, without any apparent governing by the process of natural selection.

The conclusion which we may reach, therefore, is that both natural selection and mutation operate in the development of new forms from old. The variations, for which Darwin was at a complete loss to account, are in many cases the mutations emphasized by de Vries and his followers. But to what extent climate, food, habits, and multitudinous other environmental factors, coupled with such in-

ternal ones as racial old age, complicate the processes of variation and selection cannot yet be said. De Vries, in his mutation theory, supplied one of the deficiencies of Darwinism, and at the same time led scientists in general to realize that evolution is a far more complex problem than was supposed during the later portion of the last century. Darwin's primitive mudfish, with its trace of mind, and the process of natural selection, will not by any means account for the multitude of higher vertebrate forms which people, and have peopled the lands and waters of the globe.

At the same time the scientific public was awaking to the fact that evolution was an almost inconceivably complex affair, many of the post-Darwinian hypotheses began to show themselves of very doubtful importance. The theory of sexual selection, which Darwin elaborated in the "Descent of Man" began a steady decline. Such selection undoubtedly does take place, but it is not carried on to so great an extent as was once supposed. The idea of the protective value of colors and color arrangement, too, began to be doubted, although at the same time its principles became much better known and therefore more strongly emphasized by some naturalists. Inheritance of directly acquired characters was proved to be an impossibility, and much doubt was thrown upon the hypothesis of use and disuse. Instead of legs disappearing because they are not used, they are now thought to disappear because the evolutionary processes going on

within the animal demands their disappearance. What these processes are we do not know, but our frank avowal of ignorance gives us a certain confidence that we shall eventually find out.

But it is not only ideas that have changed within the last two decades; methods of study have undergone an even greater revolution. De Vries, at almost the same time he discovered mutation, rediscovered the fact that heredity was by no means so mysterious and erratic as it had been generally thought. Animals and plants, he discovered, possessed many characters which behaved in very definite ways when two varieties were crossed, and that the characters of an organism could be determined largely by the interbreeding of its ancestors. Thus arose the science of *genetics*, which seeks to find out the numerous factors underlying the various phenomena of heredity. And since heredity is the base of all evolution, genetics has for its ultimate aim the determination of the causes of that great process which is responsible for the existence of whatever animals and plants inhabit and have inhabited the earth. The geneticist is the most modern of evolutionists; he is not satisfied with finding out what has taken place in the past; he sets out to make evolution, or tiny portions of it, take place within his own laboratories and greenhouses.

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Today, despite the assertions of a few of its opponents, the theory of organic evolution is more thoroughly alive than it has ever been

before. Paleontologists are studying their fossil shells and corals and bones in order to find out what has taken place during the millions upon millions of years during which living things have inhabited our planet. Anatomists are studying the bodies of modern animals, from the simplest to the highest, to determine their relationships one to the other; embryologists are tracing out the evolution of the individual in his life before birth. The geneticists are breeding plants, rabbits, mice, fishes, flies, potato bugs so that they may discover what evolution is doing today. Everywhere men are studying, comparing, experimenting. Their purpose is not to discover whether or not evolution is a fact; on that point they have long ago been satisfied. They are trying to find out how it operates and what forms it has produced; how differences arise among organisms, and what are their effects, and by what means they are passed from one generation to another until they become part and parcel of the inheritance, thereby establishing a new species.